U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-260 151

PRELIMINARY WATER QUALITY CONTROL STUDY. DOLORES RIVER, PARADOX VALLEY, MONTROSE COUNTY, COLORADO

PUBLIC HEALTH SERVICE, DENVER, COLORADO

OCTOBER 1964

258181

PB 260 151

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-260 151
4. Title and Subtitle Preliminary Water Quality Control Study. Dolores River, Paradox Valley, Montrose County, Colorado.			5. Report Date Oct 64 6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Public Health Service, Denver, Colo. Div. of Water Supply and Pollution Control.			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered 14.

15. Supplementary Notes

Report on Colorado River Basin Water Quality Control Project.

16. Abstracts

The overall objective of this project is to eliminate the contribution of the total dissolved solids (TDS) coming from Paradox Valley and thereby improve the quality of water for downstream water uses. The method found to be most feasible to accomplish this objective is the construction of a reservoir downstream from Paradox Valley to contain the brine discharges. Benefits for the reduction of TDS have not been calculated but appear to be in excess of the construction cost. A bibliography and maps are included.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

*Water quality
Colorado
Dolores River
Hydrology
*Water pollution control
Construction costs
Cost estimates
Rivers
Stream flow
Pollution abatement
Water pollution control equipment
Brines

17c. COSATI Field/Group 13B

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 23
	20. Security Class (This Page UNCLASSIFIED	22. Price $3.50-3.00

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

PRELIMINARY WATER QUALITY CONTROL STUDY

DOLORES RIVER

PARADOX VALLEY

MONTROSE COUNTY, COLORADO

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VIII
Denver, Colorado

Colorado River Basin Water Quality Control Project

October 1964

TABLE OF CONTENTS

	Page
INTRODUCTION	1
SUMMARY AND CONCLUSIONS	1
DESCRIPTION OF AREA	2
DESCRIPTION OF PROJECT AREA	3
HYDROLOGY	4
WATER QUALITY	5
GENERAL CONTROL METHODS	5
CONSTRUCTION METHODS	8
CONSTRUCTION COSTS	10
BENEFITS OF CONTROL	12
FUTURE DEVELOPMENTS	12
BIBLIOGRAPHY	14
AREA MAP	15
PROJECT MAP	16

PRELIMINARY WATER QUALITY CONTROL STUDY
DOLORES RIVER
PARADOX VALLEY

INTRODUCTION

The overall objective of this project is to eliminate the contribution of the total dissolved solids (TDS) coming from Paradox Valley. Through the elimination of this contribution, the quality of water for downstream water uses will be improved. It is estimated that 234,000 tons per year of TDS are contributed through the stretch where the Dolores River flows through the Paradox Valley. This amount of TDS reaches the Dolores River through various means. The runoff from Paradox Valley reaches the Dolores River after percolating through the salt formations. This, along with evapotranspiration use of native vegetation, increases the concentration of the ground water effluent to approximately 25,000 ppm. Other sources of salt are return flows from the 3,000 acres of irrigation in West Paradox Valley, and the discharge of bank storage to the Dolores River at periods of low flow.

SUMMARY

The Dolores River flows through Paradox Valley which was formed by the plastic upward flowage of the underlying salt of the Paradox member of the Hermosa formation of Pennsylvanian age.

The natural condition causes an increase of salinity in the Dolores River below Paradox Valley of approximately 640 tons per day.

Methods to control this inflow of TDS have been proposed, along with tentative cost figures.

CONCLUSIONS

After evaluation of various methods of control, the method most feasible is the construction of a reservoir downstream from Paradox Valley to contain

the brine discharges from Paradox Valley.

Benefits for the reduction of TDS have not been calculated but appear to be in excess of the cost of construction.

It is important that some method of control be initiated at this time; moreover, if future proposed irrigation projects in Paradox Valley are constructed, it becomes more important.

DESCRIPTION OF AREA

The Dolores River area is in the Upper Colorado River Basin in southwestern Colorado, just east of the Utah-Colorado state line. The Dolores River heads in the La Plata and San Miguel mountains. It flow southwest from the mountains towards the town of Dolores where it abruptly changes its course to the northwest. It continues to the northwest to its confluence with the Colorado River, about 25 miles northeast of Moab, Utah, or river-mile 1024 on the Colorado River. The San Miguel River joins the Dolores River at river-mile 67 on the Dolores River.

The climate in the area is variable, but in general it is temperate and semi-arid. Precipitation ranges from 11 inches in the west to over 30 inches in the mountainous sections. Temperature variation in the lower elevation ranges from 35°F below zero to 105°F, with a mean annual temperature of 45-50°F. Lake evaporation is approximately 36 inches annually.

The principal municipalities in the area, all in Colorado, along with their 1960 population figures are: Rico - 353; Dolores - 805; and Uravan - 1005.

The mining and processing of uranium is the largest industrial activity. Union Carbide Nuclear Company has a uranium plant at Uravan on the San Miguel River. At Rico, on the Dolores River, sulphuric acid is manufactured from pyrites obtained at local mines.

The Dolores River is practically inaccessible from Uravan to its confluence with the Colorado River, with the exception of Neptune Bridge 8 miles below Uravan, and at Gateway, Colorado. Upstream from the confluence of the San Miguel River, the Dolores River is accessible to Highway 90 at Bedrock, by Highway 80 at Slick Rock, and by Highway 145 at Dolores. (See Location Map, Figure No. 1).

NOT CORRECT ! AAR

Due to the remoteness and the topography of the area, the area is sparsely populated and depends mainly upon the mining industry. While it has been predicted that the population and economic growth will increase 50% in the next 50 years, this will depend upon the increase in the mineral industry and perhaps in the commercial utilization of the natural salts and potash in the area, along with recreation activities, i.e. hunting and winter sports.

DESCRIPTION OF PROJECT AREA

Paradox Valley is located in Montrose County in southwestern Colorado. The Dolores River transversely cuts across Paradox Valley 80 miles upstream from the confluence of the Dolores River with the Colorado River. The 40-mile long valley is approximately 5 1/2 miles wide at this point. The total drainage area is 206 square miles. The valley is a dominant structural feature of the Paradox Basin that extends west and south of the Uncompaghre Uplift to southeast Utah. Paradox Valley is a northwest-southeast trending anticlinal structure that was formed by the plastic upward flowage of the underlying salt of the Paradox member of the Hermosa Formation of Pennsylvanian age. The subsequent erosion and breaching of the anticline along the longitudinal axis has resulted in the present day exposure of the Pennsylvanian and Permian salt and gypsum beds with a thin discontinuous cover of alluvium in the bottom of the valley. East and West Paradox Creeks provide surface drainage along

the longitudinal axis of the valley to the Dolores River.

The strata underlying Paradox Valley is composed of shales, siltstones, limestones, gypsum, and salt. Local precipitation percolates through the alluvial cover to the underlying salt beds and forms a brine in the water table aquifer. Recharge from the Dolores River channel, as it traverses the valley, also adds to the brine in the aquifer. Discharge from the brine aquifer occurs from diffuse spring areas along the downstream section of the Dolores River as it leaves the Paradox Valley.

Brine wells in Paradox Valley supply commercial needs which are transported both by truck and pipeline. The brine from the aquifer has a total dissolved salt concentration of 257,000 ppm. As determined from oil well test holes, the aquifer is composed of about 75 per cent salt and is about 10,000 feet thick.

Paradox Valley Basin is almost equally divided west and east of the Dolores River. East Paradox Valley is barren, covered with junipers and sage brush. The low land along the Dolores River is marshy with extensive growths of salt cedar and other phreatophytes. West Paradox Valley is similar in vegetation with the exception of approximately 3,000 acres of land being irrigated through releases from Buckeye Reservoir into the West Paradox Creek. Five hundred and sixty acres of the lower portion of West Paradox Valley, adjacent to the Dolores River, are being irrigated through pumps and pipelines from the Dolores River above the Bedrock Bridge (see Map of Project Area, Figure 2).

HYDROLOGY

The following Table I lists the location of USGS gaging stations on the Dolores and San Miguel Rivers with their years of record, and average, maximum and minimum flows in cubic feet per second for the years of record.

TABLE I

Existing U. S. Geological Survey Gaging Stations

USGS Sta. Number	Location	Yrs. of Record	Flows		
			Average cfs	Maximum cfs	Minimum cfs
9-1665	Dolores River at Dolores, Colorado	51	440	10,000	0
9-1770	San Miguel River at Uravan, Colorado	8	347	6,690	14
9-1800	Dolores River near Cisco, Utah	12	699	17,400	3.4

WATER QUALITY

Listed in Table II are the TDS concentrations for the Dolores River at identified locations from a survey made by the Colorado River Basin Water Quality Control Project in March 12-23, 1962.

Table III shows the flow and quality of the Dolores River at Cisco for the water year ending September 1962, along with flows and estimated quality of the Dolores River at Dolores and San Miguel River at Uravan.

Table III also shows the effect of the control of salinity from Paradox Valley assuming construction of reservoir as described below.

Based upon the aforementioned tables, the average contribution of TDS from the Paradox Valley into the Dolores River would be 640 tons per day with a maximum contribution of 1250 tons per day.

GENERAL CONTROL METHODS

In order to eliminate the above phenomena, the following control methods were considered:

(a) The lining, or rendering impervious by other means, the channel of the Dolores River through Paradox Valley, to prevent recharge of the underlying aquifer from the Dolores River.

TABLE II

Flow and Total Dissolved Solids Data from Project Survey,
March 12-23, 1962

Station	River Mile	Flow (cfs)	TDS ppm	TDS tons/day
Dolores River @ Bedrock	80	78	662	141
Inflow @ Paradox Valley	75	14	25000	924
Dolores River @ San Miguel	67	92	4273	1065
San Miguel @ Dolores	67	85	1245	285
Dolores River @ Neptune Bridge	62	178	3159	1516
Dolores River @ mouth	1024.0	195	2622	1481
Colorado River @ Cisco	1023	3938	782	8310
Colorado River @ Cisco (after project)	1023	3924	700	7386

TABLE III

Flow and Quality Data for Period Before and After Construction of Salinity Control Project

	Prior to Control Project						Subsequent to Control Project	
	San Miguel R. @ Uravan, Colo. USGS Gage Sta. No. 9-1770		Dolores R. @ Dolores, Colo., USGS Gage Sta. No. 9-1665		Dolores R. @ Cisco, Utah, USGS Gage Sta. No. 9-1800		Dolores River @ Cisco, Utah	
1961	Flow (cfs)	TDS (a) tons/day	Flow (cfs)	TDS(b) tons/day	Flow (cfs)	TDS(c) tons/day	Flow(d) (cfs)	TDS tons/day
Oct.	214	283	168	100	292	933	292	438
Nov.	140	235	110	75	200	1090	200	388
Dec.	95	200	55	41	154	1050	154	322
1962								
Jan.	78	182	55	41	131	945	131	295
Feb.	177	258	90	57	449	1170	449	400
Mar.	129	225	80	53	273	1425	273	393
Apr.	1176	600	1107	362	3195	2360	3195	1102
May	832	510	1554	460	2186	1520	2186	1025
June	654	460	1209	385	1351	1250	1351	885
July	406	375	373	175	533	1080	533	603
Aug.	120	220	228	125	126	617	126	372
Sep.	98	202	117	78	107	804	107	332
Mean	343	312	429	162	747	1185	747	545

(a) Taken from flow-quality data in "Water Resources Study and Public Health Aspects of the San Miguel Project", U.S. Public Health Service, Denver, Colorado, June 1964.

(b) Taken from flow-quality curve from data in Upper Basin Report, USGS and USBR, 1963.

(c) Taken from "Chemical Analyses of Surface Waters in Utah, October 1959-September 1962" dated September 1963.

(d) Flows not corrected for reservoir evaporation losses.

(b) The utilization of wells to lower the ground-water table of the brine aquifer so that there would be no natural discharge of brine to the Dolores River.

(c) The construction of a reservoir upstream from Paradox Valley for the purpose of regulating the discharge from the Dolores River in order to minimize the required size of the lined channel through Paradox Valley.

(d) The construction of a dam downstream of Paradox Valley in order to retain the brine that discharges into the Dolores River.

CONSTRUCTION METHODS

The first three methods of control listed above are interrelated to the extent that wells would have to be utilized to lower the ground water, or at least dispose of ground-water discharge, even if the canal is lined and even if the upstream dam is constructed. The amount of subsurface runoff was estimated to be approximately 10 cubic feet per second. The methods proposed to control this ground-water discharge to the river, as well as recharge from the Dolores River, would be the construction of a concrete-lined channel through the Paradox Valley or the installation of cut-off walls on either side of the channel through the valley. A more economical solution may be the channelization of the river and the use of bentonite for the control of seepage.

Under method (b) above, the utilization of wells to lower the ground-water table of the brine aquifer, and thereby prevent natural discharge of brine to the Dolores River, would be used either with the canals lined or unlined. The latter case would require additional pumping as it would be necessary to pump both recharge from the Dolores River and natural runoff from Paradox Valley. This same argument holds for method (c), the construction of a dam

upstream from Paradox Valley because it would still be necessary to prevent the discharge of subsurface runoff to the Dolores River. Additional pumping would be required if the channel was not lined.

In all of the first three methods, pumping from the ground-water aquifer is required, and the disposal of the brine would be a problem. The disposal of the brine could be handled through injection wells into the deeper aquifer or disposal by ponding and evaporation. In both methods of disposal, the cost of the water diverted and lost in the process would be a contributing factor in the overall plan. This might be counteracted somewhat if a disposal method could be associated with the commercial utilization of brine for salt production.

The last method of control listed, method (d), seems to be more feasible. This is the construction of a dam downstream from Paradox Valley within the stretch of the Dolores River upstream from the confluence of the San Miguel River. In this area, the underground shale formation would act as an impervious cut-off wall. The dam would form a reservoir through the Paradox Valley flooding approximately 800-2300 acres, depending upon the height of the dam. The reservoir would maintain a positive head on the ground-water effluent. Also, due to the greater density of the ground-water effluent, a reservoir would restrict the brine solution to the lower level and minimize mixing. This reservoir would, in effect, be a settling basin for the brine discharging from the ground-water aquifer. The primary purpose of this reservoir would be to control the brine, but there could be associated recreational benefits. A disadvantage of the reservoir, however, is that there are water losses due to evaporation and the value of the water lost must be included in the cost of the reservoir. Two high-water elevations were considered. At

the lower elevation (4940') the dam would be, in effect, an ogee spillway and the reservoir volume would be reserved only for the storage of brine solution. At the higher elevation (4960') runoff could be stored and the downstream flow regulated with possible beneficial effects on the lower Dolores River during periods of low flow. Considering precipitation and evaporation, the capacity of the reservoir at the lower elevation would have useful storage life of some 150 years before being completely filled with salt.

The cost of these various alternative solutions are tabulated in the following section.

To summarize, three alternative methods were proposed for controlling salinity by pumping from the ground-water aquifer. For each of these alternative methods, either underground or surface disposal of the brine would be necessary. The fourth salinity control method proposed would require no pumping, but would involve the construction of a reservoir downstream from Paradox Valley. In all these control methods, a possibility that should be explored is the commercial use of the brine which would minimize the loss of the water through surface or underground disposal methods.

CONSTRUCTION COSTS

All of the aforementioned methods of control are listed in Table IV with their construction cost and an estimated annual cost based on 50 years estimated life.

The estimated costs are only tentative and preliminary figures. Detailed studies would have to be made to develop more accurate figures and the most appropriate control method.

By comparing the annual cost figures of the above methods, the plan to construct a downstream reservoir at elevation 4940 is the most economical method.

TABLE IV

Construction Costs

Methods	Construction Cost	Annual Cost
Pumping to disposal ponds without lining of channel	$ 2,450,000	$ 92,000
Pumping to injection wells without lining	265,000*	32,200
Pumping to disposal ponds with channel lining	1,490,000**	251,800
Pumping to injection wells with lining	405,000	226,100
Pumping to disposal ponds with lining of channel and upstream reservoir	3,740,000	148,500
Pumping to injection well with canal lining and reservoir	2,655,000	123,800
Pumping to disposal ponds with upstream reservoir and no lining	2,900,000	104,700
Pumping to injection wells with upstream reservoir and no lining	2,715,000	85,300
Construction reservoir downstream at elevation 4940	1,095,200	24,600
Construction reservoir downstream at elevation 4960	2,162,370	51,200

* Assumed that existing well in the area can be used.

** Pumping with lining amounts to half of pumping without lining.

BENEFITS OF CONTROL

All of the above methods of control were assumed to be equally effective as salinity control methods. The salinity contribution of Paradox Valley is approximately 640 tons per day, or 234,000 tons per year. The reduction of the total load would amount to a reduction in TDS concentration of approximately 25 ppm in the Colorado River at Cisco. The monetary benefits for this reduction of salinity in the Colorado River have not been calculated at this time, but based upon preliminary figures it appears that they will be greater than the cost of control. The construction of a reservoir would have the additional advantage of the saving of water over the use of injection wells or disposal ponds. Another benefit which has not been included would be the use of the reservoir for recreational purposes, estimated to be approximately $25,000 per annum but would require some additional facilities.

FUTURE DEVELOPMENTS

Proposed future developments upstream in the Dolores and San Miguel Rivers will deplete the present flows in these rivers. An estimated future condition based on 1962 flows is shown in the following Table V. A present proposal to irrigate the East Paradox Valley from the San Miguel River will increase the salinity contribution in the Dolores River at the project location. The amount of this increase in concentration has not been calculated at this time. At the same time, if the proposed projects are constructed, it is necessary that some control method be initiated in this project area.

TABLE V

Flow and Quality Conditions following Construction of Dolores & San Miguel Projects and Salinity Control Project

	San Miguel River @ Uravan, Colorado USGS Station #9-1770		Dolores River @ Dolores, Colorado USGS Station #9-1665		Dolores River @ Cisco, Utah USGS Station #9-1800	
	Flow (cfs)	TDS tons/day	Flow (cfs)	TDS tons/day	Flow (cfs)	TDS tons/day
1961						
October	45	60	50	30	73	90
November	141	235	110	75	200	310
December	95	200	55	41	154	241
1962						
January	78	182	55	41	131	223
February	178	258	90	57	449	315
March	129	225	80	53	273	278
April	993	510	770	251	2470	761
May	680	416	1230	364	1755	780
June	470	331	872	278	974	609
July	229	211	50	24	191	235
August	45	83	50	27	34	110
September	45	92	50	33	47	125
Mean	261	233	288	106	562	339

BIBLIOGRAPHY

1. Water Resources Study and Public Health Aspects of the San Miguel Project, Colorado. U. S. Department of Health, Education, and Welfare, PHS, Region VIII, Denver, Colorado, June 1964.

2. Chemical Analyses of Surface Waters in Utah, October 1959 - September 1962. U. S. Department of Interior, Geological Survey, Water Resources Division, September 1963.

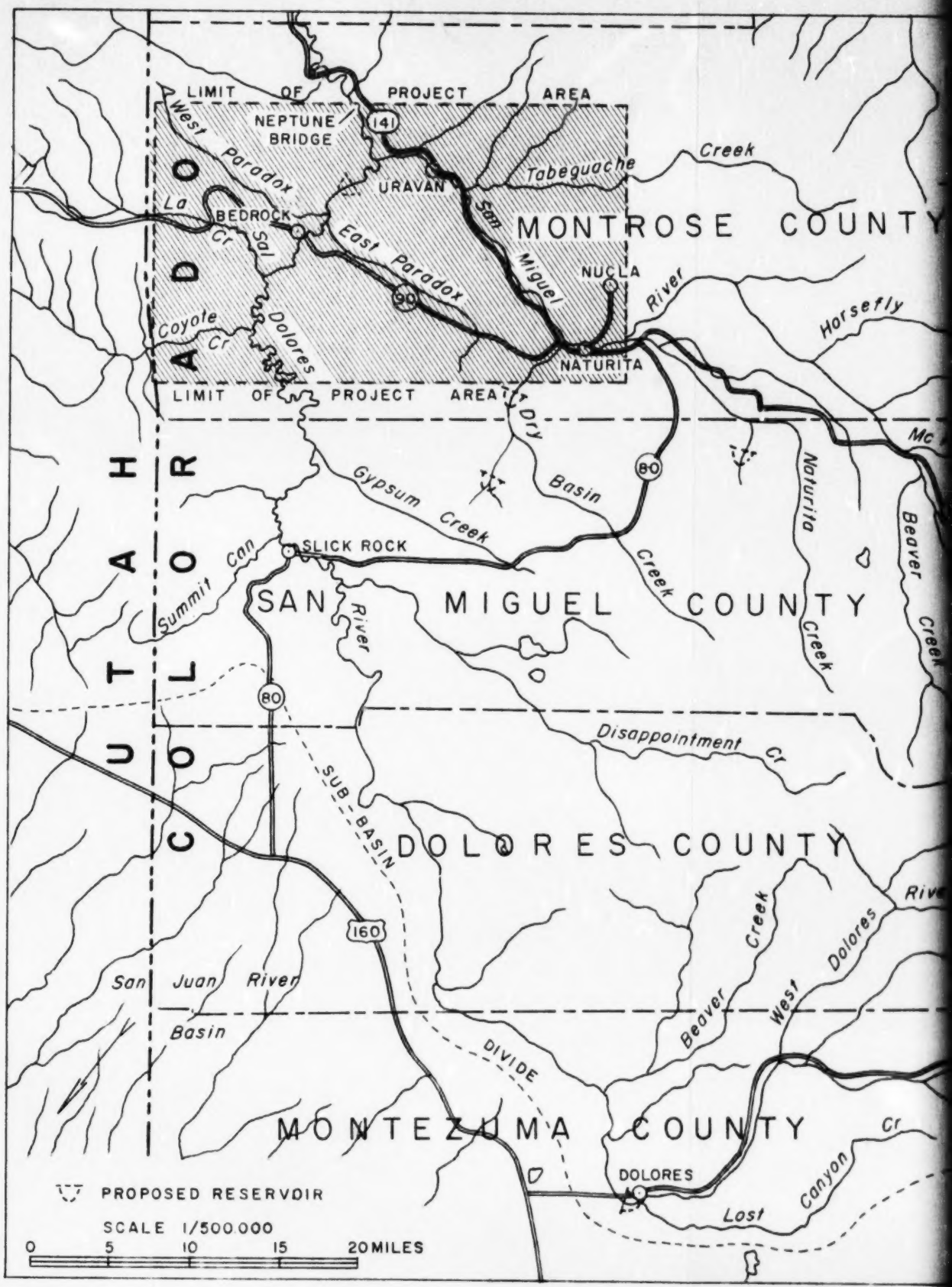
3. Surface Water Records of Utah. U. S. Department of Interior, Geological Survey, Water Resources Division, 1962.

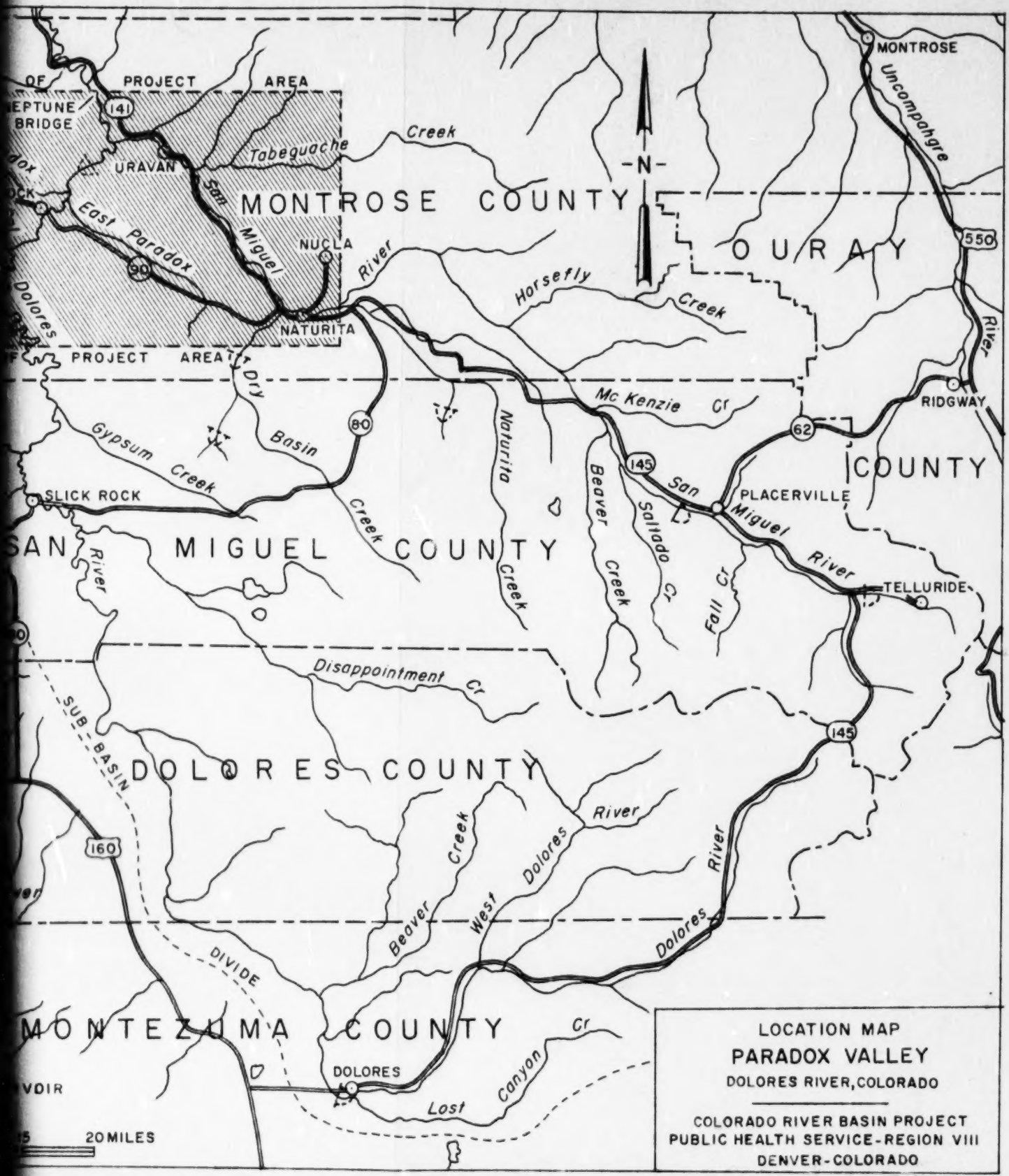
4. Surface Water Records of Colorado. U. S. Department of Interior, Geological Survey, Water Resources Division, 1962.

5. Dolores Project, Colorado. Feasibility Report. U. S. Department of Interior, Bureau of Reclamation, Salt Lake City, Utah, May 1962.

6. Water Resources of the Upper Colorado River Basin - Basic Data. U. S. Department of Interior, Geological Survey Professional Paper 442, 1964.

7. Geologic and Topographic Quadrangle Maps. U. S. Department of Interior, Geological Survey.

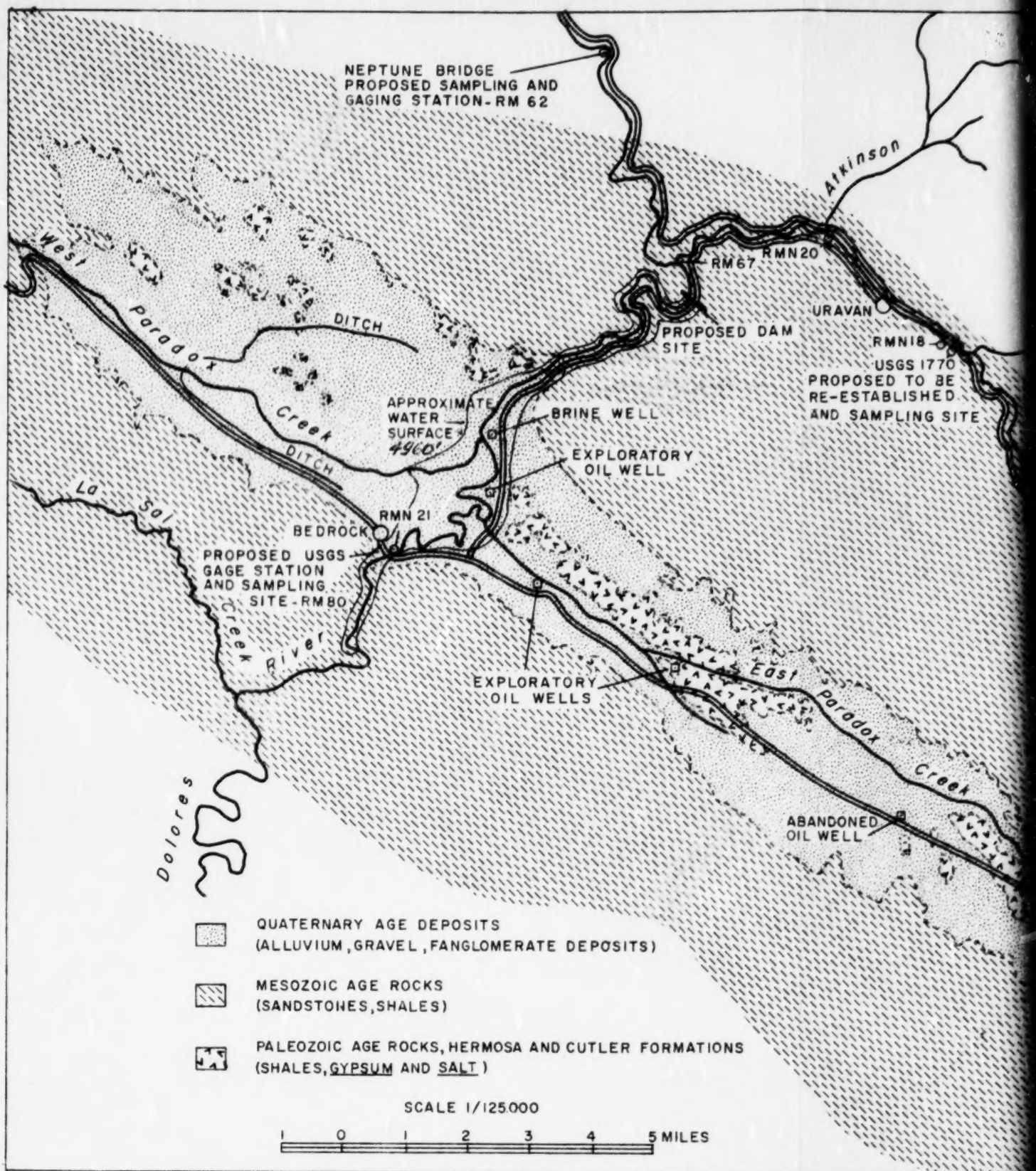

LIMIT OF PROJECT AREA
NEPTUNE BRIDGE
141
West Paradox
La Sal Cr
BEDROCK
URAVAN
Tabequache Creek
San Miguel
East Paradox
90
NUCLA
River
Horsefly
Coyote Cr
Dolores
NATURITA
MONTROSE COUNTY
LIMIT OF PROJECT AREA
Dry
Gypsum Creek
Basin
80
Naturita Creek
Beaver Creek
SLICK ROCK
Summit Can
SAN MIGUEL COUNTY
River
Disappointment Cr
SUB-BASIN
DOLORES COUNTY
160
San Juan River
Basin
DIVIDE
Beaver Creek
West Dolores
MONTEZUMA COUNTY
DOLORES
Lost Canyon Cr
PROPOSED RESERVOIR
SCALE 1/500,000
0 5 10 15 20 MILES



LOCATION MAP
PARADOX VALLEY
DOLORES RIVER, COLORADO

COLORADO RIVER BASIN PROJECT
PUBLIC HEALTH SERVICE-REGION VIII
DENVER-COLORADO

Figure No. 1


NEPTUNE BRIDGE
PROPOSED SAMPLING AND
GAGING STATION - RM 62
Atkinson
RM67
RMN20
URAVAN
RMN18
USGS 1770
PROPOSED TO BE
RE-ESTABLISHED
AND SAMPLING SITE
PROPOSED DAM
SITE
West Paradox
DITCH
Creek
DITCH
APPROXIMATE
WATER
SURFACE
4960'
BRINE WELL
EXPLORATORY
OIL WELL
La Sal
RMN 21
BEDROCK
PROPOSED USGS
GAGE STATION
AND SAMPLING
SITE - RM80
Creek
River
Dolores
EXPLORATORY
OIL WELLS
East Paradox Creek
ABANDONED
OIL WELL
QUATERNARY AGE DEPOSITS
(ALLUVIUM, GRAVEL, FANGLOMERATE DEPOSITS)
MESOZOIC AGE ROCKS
(SANDSTONES, SHALES)
PALEOZOIC AGE ROCKS, HERMOSA AND CUTLER FORMATIONS
(SHALES, GYPSUM AND SALT)
SCALE 1/125000
1 0 1 2 3 4 5 MILES

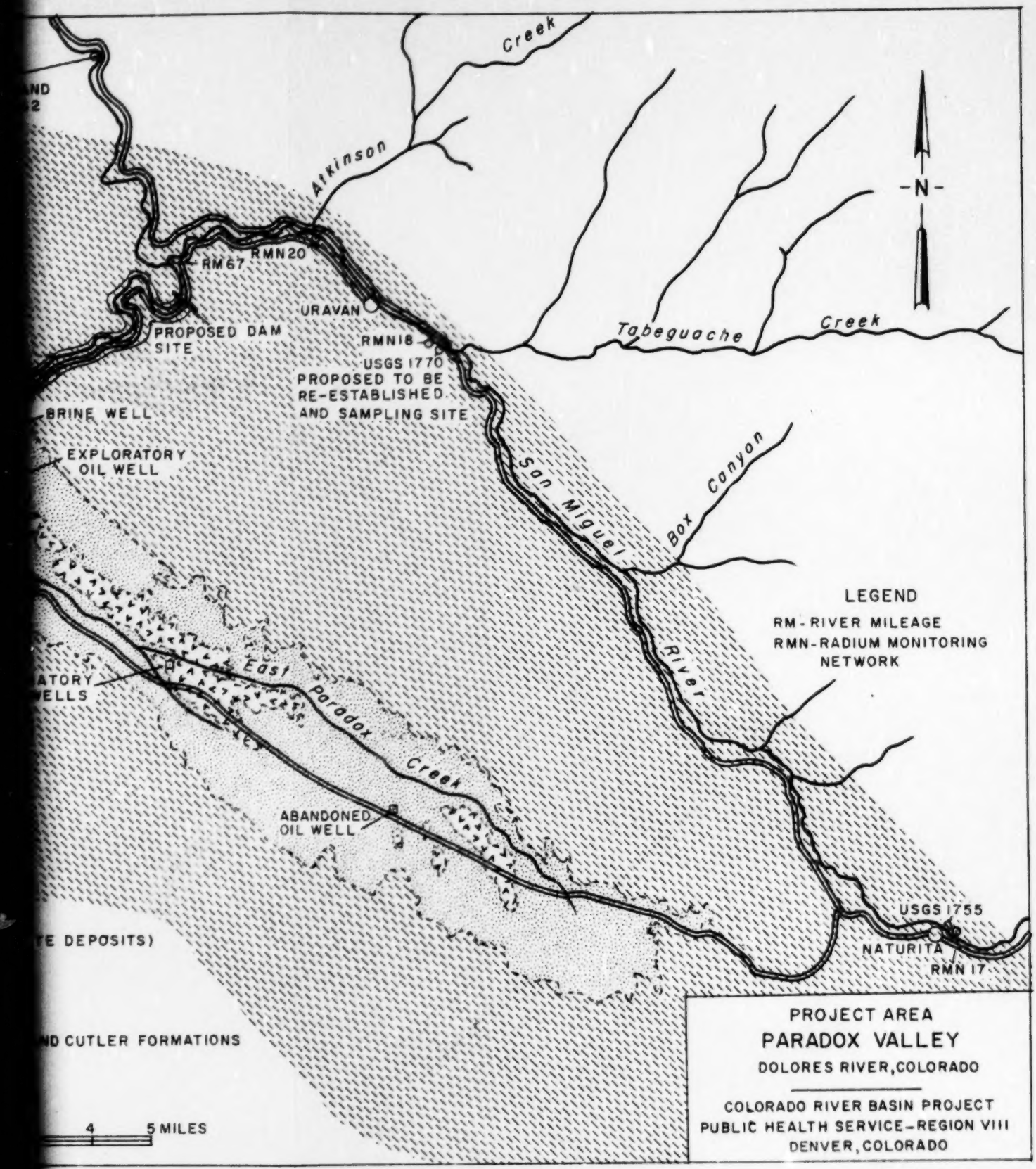

Creek
Atkinson
N
RM67
RMN20
URAVAN
PROPOSED DAM SITE
RMN18
USGS 1770
PROPOSED TO BE RE-ESTABLISHED AND SAMPLING SITE
Tabeguache
Creek
BRINE WELL
EXPLORATORY OIL WELL
San Miguel
Box Canyon
LEGEND
RM - RIVER MILEAGE
RMN - RADIUM MONITORING NETWORK
River
East
Paradox
Creek
ABANDONED OIL WELL
USGS 1755
NATURITA
RMN 17
4
5 MILES
PROJECT AREA
PARADOX VALLEY
DOLORES RIVER, COLORADO
COLORADO RIVER BASIN PROJECT
PUBLIC HEALTH SERVICE - REGION VIII
DENVER, COLORADO

Figure No. 2